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Memorandum

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Original signed on 4/7/05 by
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Subject: Surfacing Design Guidelines

In order to reduce confusion and promote consistency in surfacing designs, the Materials Bureau offers these guidelines for the development of surfacing typical sections. While this memo is primarily directed toward design consultants, it provides guidelines that are also being used internally.

Plant Mix Surfacing

Plant mix surfacing (PMS) type is selected mainly on the project quantity. Table 1 is a general guide. The total contract quantity should be considered when multiple projects are going to be tied and let under one contract. Factors to be considered would be the proximity of the projects to each other, traffic conditions (ESAL's) and available materials types.

Project Quantity (Metric or English)	**Plant Mix Type**	**QA**	**Lift Thickness**	
			Min ~ Max	**Recommended**
> 20,000 tons	½ in (12.5mm) Grade S	Yes, Volumetrics	0.12 ~ 0.20 ft (35 ~ 60mm)	0.15 ft (45mm)
	¾ in (19mm) Grade S		0.15 ~ 0.30 ft (45 ~ 90mm)	0.15 ~ 0.25 ft (45-75mm)
2000 – 20000 tons	½ in (12.5 mm) Grade S	Yes, Non-Volumetrics	0.12 ~ 0.20 ft (35 ~ 60mm)	0.15 ft (45mm)
	¾ in (19 mm) Grade S		0.15 ~ 0.30 ft (45 ~ 90mm)	0.15 ~ 0.25 ft (45-75mm)
< 2,000 tons	Grade D Commercial Grade B, Special Cases	No	0.15 ~ 0.23 ft (45 ~ 70mm)	0.15 ~ 0.23 ft (45-70mm)

Table 1

The tonnage limits given in Table 1 are general guidelines. There will be situations where engineering judgment will need to be used when selecting the type of PMS to specify. In addition to the guidance in Table 1, other factors such as traffic volume, functional classification of the roadway, and project location should be taken into account. An example would be an intersection reconstruction project with high ADT and requiring 1,200 tons of plant mix. Grade S Non-Volumetric should be specified, not Grade D commercial.

The difference between Grade S Volumetric and Non-volumetric is the method of QA testing/control MDT uses during production of the plant mix. Volumetric is not as effective at ensuring the production of quality plant mix at low volumes as the Non-volumetric version.

When using Grade S, the selection of nominal aggregate size, 1/2 in (12.5 mm) or ¾ in (19 mm), should be based on design thickness and daily ESAL's. The two sizes are considered equivalent structurally. In addition to Table 1, use the following as guidance:

1. On thin lift overlays, ¾ in (19mm) Grade S should be used when the overlay thickness is greater than 0.15 ft (45mm).
2. On projects with one 0.15 ft (45mm) lift or 0.30 ft (90mm) of total surfacing surfacing, ¾ in (19mm) Grade S should be used on roadways with 41 daily ESALs or greater.
3. On projects with one 0.15 ft (45mm) lift or 0.30 ft (90 mm) of total surfacing, ½ in (12.5mm) Grade S should be used on roadways with less than 41 daily ESALs.
4. Thicker lifts should no longer be specified due to compaction concerns. On projects where a 0.20 ft (60mm) overlay is not needed for structure, then a 0.15 ft (45mm) overlay should be used. Revisions to the Grade S specifications over the past couple of year have eliminated the compaction issues associated with the 0.15 ft (45mm) lifts.

The ½ in (12.5mm) Grade S usually has a higher binder content than the ¾ in (19mm). There are separate bid items for the ½ in (12.5mm) and the ¾ in (19mm). Care should be taken to use the proper bid item.

The selection of plant mix type on smaller projects should be made based on traffic conditions (ESAL's) and available materials types. Use the following as guidance also:

1. Consider the use of Grade S on smaller projects where the daily ESALs > 300.
2. Do not use Grade C. Use Grade D commercial where Grade C commercial was traditionally used.

3. Grade B may be used for paving a bike path or other feature that will not be chip sealed. However, Grade B should only be used where there is a significant amount of paving involved (>500 tons) and heavy vehicle loading is not anticipated. Do not use Grade B for bike paths or other features requiring less than 500 tons or that are subject to heavy vehicle loading. Specify Grade D commercial or Grade S, if it is being specified for the remainder of the contract paving, along with a chip seal to alleviate any permeability concerns.

The recommended Plant Mix thickness for reconstruction projects is given in Table 2. The number of lifts should not be specified in the plans unless it is an urban section. The additional compactive effort required for the proper compaction of thicker sections is not desirable in urban areas where damage to adjacent structures may result. In other instances the contractor should be allowed to choose how to place the surfacing based on their equipment and overall operation.

ESAL's (Daily)	Plant Mix Thickness
> 300	0.40 - 0.50 ft (120 – 150mm)
200 – 300	0.30 – 0.40 ft (90 – 120mm)
< 200	0.30 ft (90mm)
Other Situations	**Plant Mix Thickness**
Urban Curb & Gutter	0.39 ft (120 – 150mm)
All Interstate Pavements	0.50 ft minimum (150mm minimum)

Table 2

Leveling

Leveling is almost always necessary on resurfacing projects where a single lift, 0.2 ft (60 mm) or less, of plant mix surfacing is specified. Include sufficient quantities of Plant Mix Surfacing to accomplish the leveling in each project. The determination of the proper quantity should be made based on the condition of the existing roadway and through discussions with District design and construction personnel. Leveling is used to correct surface defects such as dips, deteriorating pavement (alligator cracking and potholes), and rutting prior to placing the overlay. It is also used to mitigate the effects of crack sealant on the overlay. If a conscious decision is made to exclude leveling from a contract or to provide significantly less than is required, ensure the Ride Specification is excluded from that contract.

Leveling quantities should not exceed 25% of the typical quantity for the planned overlay. If more than 25% is required, it is an indicator the project is not a good candidate for a single lift overlay. The exception is situations where it is determined additional plant mix is necessary due to the presence of crack sealant in the existing surface. In those instances it is necessary to place a thin lift, 0.07 ft (21mm), of surfacing prior to the overlay in order to prevent problems due to crack sealant expanding and displacing the final lift of surfacing. This leveling lift is only placed on the travel lanes, 24 ft (7.2 m) on

two lane roadways.

If greater than 0.15 ft (45mm) of plant mix is required structurally, it may be desirable to reduce the overlay section called out in the plans to 0.15 ft (45 mm) and include the remaining quantity from the additional depth in the leveling quantity. For example, if it is determined a 0.20 ft (60 mm) overlay is necessary and the project is also going to require a leveling lift to mitigate the crack sealant, the plans should specify a 0.15 ft (45 mm) overlay and include the remaining 0.05 ft (15 mm) in the leveling quantity. The full 0.20 ft (60mm) will be placed on the roadway for structure, it's just being done in two different operations. This minimizes the quantity of plant mix required to achieve the desired final product.

PG Binders

MDT uses LTPPBind software with the LTPP high- and low-temperature models for selecting the basic binder grade. The high-temperature reliability target should always be 90% or greater. Low-temperature reliability differs based on whether or not the project is an overlay. If the project is an overlay, the new overlay will probably exhibit some reflective cracking and the low-temperature reliability should not be less than 50%. If the project is not an overlay the low-temperature reliability should be 90% or greater.

The basic binder grade, selected using LTPPBind, is adjusted for traffic volume and load rate according to Table 3, taken from the AASHTO Superpave Volumetric Mix Design specification, to determine the adjusted binder grade. These adjustments affect the high-temperature grade only.

Design ESALs,[b]		Adjustment to the High-Temperature Grade of the Binder[a]		
		Traffic Load Rate		
Daily	20-year ESALs (million)	Standing[c]	Slow[d]	Standard[e]
< 41	< 0.3			
41 to <410	0.3 to <3	2	1	—
410 to <1370	3 to <10	2	1	—
1370 to <4100	10 to <30	2	1	*f*
≥4100	≥30	2	1	1

Table 3

[a] Increase the high-temperature grade by the number of grade equivalents indicated (one grade is equivalent to 6°C).

[b] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[c] Standing Traffic—where the average traffic speed is less than 20 km/h.

[d] Slow Traffic—where the average traffic speed ranges from 20 to 70 km/h.

[e] Standard Traffic—where the average traffic speed is greater than 70 km/h.

[f] Consideration should be given to increasing the high-temperature grade by one grade equivalent.

Often we will want to insure we are specifying a polymer-modified binder. As a general guide, if the range between the high and low temperature grade is more then 90 degrees, polymer modification will be necessary to meet specification. For example, the range for a PG 64-28 is 64 + 28 = 92. This will be polymer modified.

MDT typically uses the PG binder grades shown in Table 4. The relative cost information is approximate and should be used as a general guide only.

Binder Grade	Approximate Relative Cost
PG 70-28	1.05
PG 64-34	1.1
PG 64-28	1
PG 64-22	.75
PG 58-28	.75

Table 4

Consideration should be given to using a lesser grade of PG binder in lower lifts when 0.4 ft (120 mm) or more new PMS is required. Base this decision on the models within the LTPPBind software.

Reclaimed Asphalt Pavement (RAP)

MDT does not have specifications for the use of RAP with Grade S or Grade D commercial. In the future, the use of RAP in these grades of PMS will be reevaluated.

Aggregate Base Coarse

All aggregate base coarse must meet the requirements outlined in the MDT Standard Specifications, Supplemental Specifications, or Standard Special Provisions. The current specification for Crushed Aggregate Course allows the contractor to choose between Crushed Base Course Grade 5A and Grade 6A and allows the contractor to choose to use a crushed top surfacing. This is the preferred specification for base course material.

MDT typically specifies no less than 200 mm of Crushed Aggregate Course. That depth includes any Crushed Top Surfacing that may also be placed.

Uncrushed aggregate is not acceptable for base coarse.

Cement Treated Base

MDT often uses Cement Treated Base in areas without economical access to gravel. Our minimum thickness for CTB is 200mm. The use of CTB should be considered as an alternate base material any time it is more economical than untreated aggregate base course.

Subgrade Evaluation

MDT utilizes R-Value and Resilient Modulus based subgrade evaluation methods. It is up to the designer to determine the most appropriate method of evaluation. The R-Value is a soil test that measures the support capabilities of the subgrade soils. The soil samples for the R-Value test are gathered during the soil survey. MDT can also provide deflection basin data from a Falling Weight Deflectometer for most projects if the designer wants to

backcalculate the data and use the resulting resilient modulus. Please contact John Amestoy at (406) 444 – 7651 for deflection data.

R-Value During Construction

The R-Value is often used for borrow source approval or subgrade design checks during construction. When used as a Borrow Source Approval, a specification similar to MDT Standard Special A43, Borrow Source Approval–Resistance Value should be used. The specification should use an 85th percentile R-Value statistical method for pit approval and then acceptance on the roadway by soil classification. The specification generally should not require both an R-Value and a soil class. The soil class of the material should be determined during R-Value testing and that classification used for acceptance.

R-Value testing is also used as a final design check during construction. The procedure is described in the Materials Manual. This testing is not a construction contract requirement. It is the final check of the assumed parameters during design.

Low Volume Design

The 1993 AASHTO Guide for the Design of Pavement Structures has a good section on low volume design. MDT's experience shows that this works well for < 100 daily ESALs in areas with poor soils.

Portland Cement Concrete Pavement (PCCP)

Minimum Thickness – 0.66 ft (230mm)
Dowel Bars are required

The initial construction costs of PCCP often make these pavements appear to be cost prohibitive. However, PCCP is often the least expensive pavement alternative when considering the long-term costs including initial construction costs and maintenance costs. Contact the Surfacing Design Unit if you would like a life cycle cost analysis performed to compare the long-term costs of different pavement sections (i.e. PMS vs. PCCP).

Alternate Typical Sections

To reduce the possibility of Value Engineering proposals by contractors, MDT encourages the use of alternate typical sections.

Typical Sections Utilizing Geosynthetics

MDT normally specifies geosynthetics only for known or suspected problem areas on a project. In these situations, geotextiles are used as a separation layer between special borrow and the existing ground for constructability reasons, not to reduce the thickness of the typical section. MDT is in the early stages of a research project to determine whether or not the thickness of the typical section can be reduced by using geosynthetics. The report may be found at: http://www.mdt.state.mt.us/research/projects/grfp.shtml.

The Surfacing Design Unit is currently looking for projects to include in this study.

Pavement Pulverization

MDT often uses pulverization to rehabilitate deteriorated pavements. Pulverization is typically done to a maximum depth of 0.66 ft (200mm). Crushed Aggregate Course or portland cement may be placed upon the existing road surface before pulverization to raise grade or provide additional structure. Pulverization also works well on road widening projects.

When pulverizing it is important to have a blend of pulverized plant mix surfacing and untreated aggregate surfacing. Pulverized plant mix surfacing should comprise a maximum 60% of the mix, while the remainder should be the underlying gravel surfacing, new crushed aggregate course blended during pulverization, or a combination of the two.

Closing

We encourage anyone with surfacing related questions to contact the Surfacing Design Unit.

Surfacing Design
- Dan Hill 444-3424
- Ed Shea 444-7650

Nondestructive Testing Deflection Data
- John Amestoy 444-7651

The information given is fairly general. It is based on both successes and failures on construction projects throughout the State over a long time. We want engineered solutions to a project's problems. Situations that don't fit these guidelines may be encountered. We would like early coordination on any designs that vary from these guides.

This information is intended to supplement and update the 1991 Pavement Design Manual. Please distribute this memo to all consultants involved in surfacing design.

MS: SURFACING_GUIDE_4-2005.DOC

copies: File

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